# The Teletype Discipline of Data Transfer Designed for Support of *Mariner* Mars 1971 Missions

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*This article describes the overall teletype configuration that has been developed to support the ground communications requirements established for the Mariner Mars 1971 missions. Primary emphasis is placed on the worldwide distribution of mission traffic formatted in the teletype discipline, routed through the communications switching facilities, and provided to various analysis and control centers.*

## I. Introduction

Since the early *Ranger* missions, space flight projects supported by the DSN have used the teletype discipline of data transmission to send low bit-rate data between the various locations of the tracking network during all phases of each mission. In addition to this primary use of teletype, special multiple-distribution networks were developed within the Space Flight Operations Facility (SFOF) to use teletype as a means of internally displaying not only the data received from the tracking stations but also the formatted telemetry readouts of data processing computers receiving input data from higher bit-rate disciplines of communications data transfer. Although the *Mariner* Mars 1971 Project will make extensive use of high bit-rate techniques, such as the high-speed and wide-band systems, to effect transfer of the majority of their data, their use of teletype will be greater than any mission previously supported by the DSN. Current communications planning for missions to follow *Mariner* Mars 1971 will place far greater emphasis on transmitting data using multiplexed high bit-rate techniques between the tracking stations and the SFOF. This, in addition to the planned use of specialized readout devices within the SFOF to display the outputs of the data processing computers rather than the use of teletype equipment, indicates that the teletype system developed for *Mariner* Mars 1971 may well represent the most complex and extensive application of teletype that the DSN has or will develop and employ.

In view of this, the following article has been prepared to document the overall teletype system to be used by the *Mariner* Mars 1971 Project. For purposes of clarity, certain omissions have been made intentionally, such as the use of teletype prior to the launch of the spacecraft for purposes of mission simulations, but in general the following information reflects the total use of teletype by *Mariner* Mars 1971 from the launch phase throughout the entire mission.

## II. Worldwide Teletype Network

Many separate activities located throughout the world, including tracking stations, control centers, launch activities, and communications switching centers, have requirements for the transfer of data or exchange of information between themselves using the teletype discipline in order to support the *Mariner* Mars 1971 missions. Many different types of teletype data will be generated by these activities destined in rare cases for a single recipient but far more often addressed to a multiplicity of receiving stations. Sufficient teletype circuits interconnecting these supporting activities (see Fig. 1) have been provided through the resources of the NASA Communications Network (NASCOM) in conjunction with those provided by the DSN Ground Communications Facility (DSN GCF). The teletype circuits routed to each supporting activity, regardless of its location, must always be interconnected to one of the four communications switching centers. Each of these centers has the required capability to receive input teletype traffic from the activities it is designated to support and to switch and forward such traffic to the desired recipients. The Canberra Switching Center supports DSSs 41 and 42 and the Madrid Switching Center supports DSSs 51 and 62 as well as the activities located at Tananarive (TAN) and Canary Island (CYI). The NASCOM Primary Switching Center at Greenbelt, Maryland supports the activities at Goddard Space Flight Center at Cape Kennedy, the MSFN tracking station at Ascension Island (ACN), and the activities at Bermuda (BDA) and *USNS Vanguard* (VAN). The West Coast Switching Center (WCSC) at the Jet Propulsion Laboratory supports the DSN tracking stations at Goldstone, California and provides a central communications switching center for all internal switching requirements of the SFOF. The quantity of teletype traffic, together with the complexity inherent in multiple recipients for such traffic, creates real-time switching functions at each of the switching centers which are performed by specially programmed computers, termed *Commprocessors*, that are programmed to read and react to addressing information furnished by the transmitting activity.

## III. Teletype Conventions

Each teletype circuit, interconnecting the various network locations to the Commprocessors, is assigned a teletype address, termed a *routing indicator*, consisting of four letters used by the originators of teletype traffic to indicate the desired distribution of their traffic. Table 1 lists the routing indicators assigned to the various activities supporting the *Mariner* Mars 1971 missions. In some cases, a particular routing indicator may be assigned to two circuits at a given activity, where incoming traffic will be routed to the second circuit by the Commprocessor in the event that the first circuit is busy with traffic sent at an earlier time. All switching elements of the teletype communications system carrying teletype traffic use these routing indicators, first, to direct traffic to the appropriate switching center using the first letter of the

**Table 1. Routing indicators used in support of *Mariner* Mars 1971**

| Area | Activity | Location | Routing indicators |
|---|---|---|---|
| California | DSS 12 | Goldstone | JECO, JELA, JEXC |
| | DSS 14 | Goldstone | JMAR, JMLA, JMXA |
| | SFOF | Pasadena | JSFO[a] |
| | Operations Control | Pasadena | JOCC |
| | Net Control | Pasadena | JTNC, JNCC, JNDC, JNEC |
| | WCSC | Pasadena | JJPL, JCNF |
| Florida | DSS 71 | Cape Kennedy | GKEN, GKXE |
| | RTCS | Cape Kennedy | GKAP |
| | Bldg AO | Cape Kennedy | GKYA |
| | Merritt Island (MILA) | Cape Kennedy | GMIL |
| Atlantic Ocean | MSFN-ACN | Ascension Island | GACN, GSXE |
| | | Bermuda | GBDA |
| | | Canary Island | LCYI |
| | | *USNS Vanguard* | GVAN |
| Australia | DSS 41 | Woomera | AOMJ, AOLA, AOXM |
| | DSS 42 | Tidbinbilla | ANBE, ANLA, ANXB |
| Maryland | MSFN-OC | Greenbelt | GCEN, GUNV |
| | Goddard Real-Time System (GRTS) | Greenbelt | GCDF, GDCS |
| | NASCOM | Greenbelt | GSTS |
| Spain | DSS 62 | Cebreros | LCEB, LCLA, LCXE |
| Africa | DSS 51 | Johannesburg | LJOB, LJLA, LJXO |
| | TAN | Tananarive | LTAN |

[a]Must be used in conjunction with preambles.

routing indicator and, secondly, to direct traffic to the circuits assigned to the recipient as determined and identified by the remaining letters of the routing indicator.

All teletype traffic is divided into messages, usually 15 min in duration. Each message is divided into three parts: the header, which contains among other things the addressing information (routing indicator); the body, which contains the data to be transferred; and the end-of-message, which instructs the Commprocessor to disconnect all circuits established by the header.

In the special case of the SFOF, incoming teletype messages are quite often simultaneously furnished to many areas and internal recipients. As a result, the addressing and the routing to achieve the overall teletype data flow becomes rather complex. Two separate methods of message addressing have been developed to simplify these routing problems, both basically controlled by the information provided within the messages themselves by the originators. The first of these methods, referred to as *direct addressing,* is used in those cases where the originator of teletype messages knows the desired distribution of his traffic and can therefore address his messages using the routing indicators assigned to the recipients. This is the standard method of addressing teletype traffic and is used throughout the majority of the NASCOM network. In the majority of cases, such as the transmission of tracking data to the SFOF from various tracking stations, the originator is not and cannot be aware of the real-time distribution of his data within the SFOF and thus cannot directly address his traffic to all recipients involved. In these cases, the second method of addressing is used, termed *indirect addressing,* where the originator of teletype messages addresses his traffic to a pseudo routing indicator, JSFO, which routes the traffic to the WCSC Commprocessor serving the SFOF, and additionally includes information in each message that identifies the source of the data, the spacecraft, and the type of data being sent. These three items of information, collectively, are termed a preamble, which is used by the Commprocessor to route incoming messages to any desired set of multiple recipients in the SFOF. The first part of the preamble consists of two numbers (station identifier), which indicate the source of the data. A listing of all station identifiers used in support of *Mariner* Mars 1971 is given in Table 2. The second part of the preamble consists of two numbers (spacecraft identifier) which indicate the spacecraft to which the data applies. A listing of *Mariner* Mars 1971 spacecraft identifiers is given in Table 3. The third part of the preamble consists of two numbers (message data type identifier), which indicate the type of data being transmitted. As an illustration, when DSS 12, having a station identifier of 12 (obtained from Table 2), sends a message pertaining to Mission A, having a spacecraft identifier of 84 (obtained from Table 3), containing tracking information with identifier 40 (obtained from Table 4), the preamble 12/84/40 would be entered after the routing indicator JSFO. Upon receipt of this message at the WCSC, it would be automatically routed to the data processing computers (for computation), to teleprinters (for page copy), and by means of teletype–television converters to television monitors (for viewing). The manner in which this is accomplished is discussed later in this article.

**Table 2. *Mariner* Mars 1971 station identifiers**

| Station | Identifiers | Location |
|---|---|---|
| DSS 12 | 12 | Goldstone, Calif. |
| DSS 14 | 14 | Goldstone, Calif. |
| SFOF | 20 | Pasadena, Calif. |
| DSS 41 | 41 | Woomera, Australia |
| DSS 42 | 42 | Tidbinbilla, Australia |
| DSS 51 | 51 | Johannesburg, South Africa |
| DSS 62 | 62 | Cebreros, Spain |
| DSS 71 | 71 | Cape Kennedy, Florida |
| RTCS | 70 | Cape Kennedy, Florida |
| MSFN-ACN | 75 | Ascension Island |

**Table 3. *Mariner* Mars 1971 spacecraft identifiers**

| Mission | Spacecraft identification | |
|---|---|---|
| | Actual | Simulated |
| A or H | 74 | 84 |
| B or I | 75 | 85 |
| Proof test model | 76 | 86 |

## IV. Worldwide Teletype Data Flow

Use of the assigned routing indicators and preambles in conjunction with the message switching Commprocessors and the worldwide network of teletype circuits will collectively provide the necessary teletype capabilities required to properly support the *Mariner* Mars 1971 Project. These capabilities, as provided, are necessary, but not, in themselves, sufficient to insure proper flow of teletype traffic, unless they are used in accordance

Table 4. *Mariner* Mars 1971 teletype traffic identification

| Message/ data type | Name | Description |
|---|---|---|
| 10 | Operations Control | Consists of computer formatted sequence of events and real-time schedules as well as manually formatted status and launch messages generated at the SFOF intended for transmission to tracking stations. |
| 20 | OPS-X | Consists of manually formatted messages sent between the SFOF Net Control and tracking stations containing information and instructions relative to a spacecraft tracking pass. |
| 21 | Trajectory | Consists of inter-range vector, state vector, *I*-matrix, orbital elements and liftoff data generated by either SFOF or RTCS intended for transmission to tracking stations. |
| 22 | RTCS predicts | Consists of predicts generated by Air Force Eastern Test Range (AFETR) RTCS intended for transmission to tracking station at Ascension Island and furnished to SFOF and MSFN-OC. |
| 23 | RTCS predicts | Consists of predicts generated by AFETR RTCS intended for transmission to DSS 51 and furnished to SFOF. |
| 24 | RTCS predicts | Consists of predicts generated by AFETR RTCS intended for transmission to DSS 62 and furnished to SFOF; generated only when requested by SFOF in real time. |
| 28 | Conference | Consists of manually prepared real-time messages between SFOF and DSN tracking stations; used only when normal voice circuits become inoperative. |
| 40 | Tracking | Consists of tracking data generated by all tracking stations (including Ascension and excluding DSS 71) intended for transmission to SFOF. |
| 42 | SFOF predicts | Consists of first set of predicts generated by SFOF intended for transmission to applicable tracking stations. |
| 43 | SFOF predicts | Consists of second set of predicts generated by SFOF intended for transmission to applicable tracking stations. |
| 44 | SFOF predicts | Consists of third set of predicts generated by SFOF intended for transmission to applicable tracking stations. |
| 45 | Pseudo residuals | Consists of first set of pseudo residuals generated by SFOF intended for SFOF internal distribution. |
| 46 | Pseudo residuals | Consists of second set of pseudo residuals generated by SFOF intended for SFOF internal distribution. |
| 47 | Pseudo residuals | Consists of third set of pseudo residuals generated by SFOF for SFOF internal distribution. |
| 50 | Telemetry | Consists of 8⅓-bit/s engineering telemetry data generated by the tracking stations intended for transmission to SFOF in event prime method of telemetry transmission (high-speed data) becomes inoperative. |
| 51 | Telemetry | Consists of 33⅓-bit/s engineering telemetry data generated by tracking stations intended for transmission to SFOF in event prime method of telemetry transmission (high-speed data) becomes inoperative. |
| 55 | Telemetry | Consists of 8⅓-bit/s engineering telemetry data and edited 50-bit/s science telemetry data generated by tracking stations intended for transmission to SFOF in event prime method of telemetry transmission (high-speed data) becomes inoperative. |
| 70 | Command | Consists of spacecraft commands generated by SFOF intended for transmission to tracking stations, and of verification of receipt of these commands generated by tracking stations intended for transmission to SFOF. |
| | Formats | Consists of various types of telemetry formats generated by SFOF (360-75) for SFOF internal distribution only. |

with preplanned instructions as developed and provided by the DSN GCF to all locations transmitting teletype data during the launch and subsequent phases of the *Mariner* Mars 1971 missions. Table 5 is a worldwide teletype data flow plan that reflects the overall planning furnished to participating locations. Those locations transmitting teletype data are listed in the left column of this table together with the types of data to be transmitted by them on each routing indicator assigned to each transmitting circuit. The remaining part of this table illustrates receipt of the transmitted data by all other locations and indicates not only the activity receiving the data but the routing indicator of that activity to be used by the transmitting location for the transfer of his traffic. All traffic intended for locations other than the SFOF is directly addressed to the recipient, while traffic intended for the SFOF may be either indirectly addressed, by use of the routing indicator JSFO and the preamble as previously discussed, or directly addressed as indicated. Thus, Table 5 reflects both the source and the recipient of all teletype data for the *Mariner* Mars 1971 missions except for the detailed distribution of teletype data within the SFOF and the backup teletype capabilities, both of which are discussed later.

## V. Teletype Message Switching

The computer programs residing in the Commprocessors, shown in Fig. 1, have been designed so as to automatically route any message, properly addressed, from any location in the network to any other location. This technique, termed *message switching,* is used throughout the teletype system and may be roughly compared to direct dialing techniques used over commercial telephone networks in that the user provides the addressing information to equipment capable of interpreting such addressing and establishing the required circuit interconnections to connect the originator to the addressed location. Thus the *routing indicator* of the teletype system is analogous to the *telephone number* of the commercial telephone network. Continuing this analogy, the first letter of the routing indicator, either A, G, L, or J for each of the four switching centers, may be compared with the telephone area codes, since the Commprocessor at each switching center provides a central switching point in the various geographical areas where tracking stations are concentrated. These stations transmit and receive teletype data from the switching centers at 100 words/min, which roughly corresponds to 50 bits/s. At each switching center, data are forwarded to other switching centers in blocks via 2400-bit/s data lines.

By inserting a routing indicator in the header of a message, a transmitting location instructs the receiving Commprocessor to route the message to the desired recipient over the teletype circuit corresponding to the chosen routing indicator. For the duration of this message, this circuit is not available to teletype traffic transmitted from other sources directed to the same routing indicator. Such traffic is held at the Commprocessor and automatically forwarded when the circuit is released upon completion of transmission of the previous message. Release of the circuit is made by the Commprocessor upon receipt of the end-of-message indicator sent by the transmitting location at the end of his message. If provisions were not otherwise made, non-transmission or non-receipt of this end-of-message indicator would result in permanent denial of the circuit to all subsequent traffic addressed to it. To prevent this from occurring, the Commprocessors are programmed to count the time intervals experienced between successive teletype characters as received from all transmitting locations. Should a time interval greater than 16 s occur, the Commprocessor interprets this as an end-of-message indicator and releases the circuit. Normally, transmitting locations are capable of formatting their output teletype traffic such that 16-s pauses between successive characters do not occur; thus, this timeout feature does not interrupt traffic. Certain types of data formats, however, are such that pauses between characters greater than 16 s will occur and additional provisions have been made to accommodate these exceptions. In these cases, the transmitting locations enter the code *AA* in the header of the messages and the receiving Commprocessor automatically substitutes a 30-min timeout in place of the 16-s limit. Should a transmitting location format traffic having pauses between characters greater than 30 min, then they must transmit an end-of-message indicator subsequent to such a break and a new header prior to resuming traffic transmission.

In addition to having the same capabilities as the other Commprocessors, the Commprocessor at the WCSC is specially programmed to multiple route received messages to many internal SFOF locations depending upon the preamble assigned to each message. Upon receipt of all messages addressed to JSFO, the WCSC Commprocessor reads the preamble and by referring to a previously entered preamble table, which cross-references preambles to multiple internal routing indicators, receives instructions to route such traffic to all such addresses. Since these preamble tables can be changed in real time by the operators of the WCSC Commprocessor, the capability exists to internally route incoming messages in any

**Table 5. *Mariner* Mars 1971 worldwide teletype data flow**

| Transmitting stations | | | Receiving stations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Space Flight Operations Facility | | | | | | | | | | | | Deep Space Instrumentation Facility | | | | | | | Goddard | | | Cape Kennedy | | | TAN | CYI | VAN | BDA | MILA |
| | | | Indirect address (JSFO) | | | | | | | | Direct address | | | | Tracking stations | | | | | | | MSFN | | GRTS | Comm | Building AO | RTCS | | | | | |
| Station | Data | Routing indicator | CPS | Comm | TTY | Operations | NAT | DSIF | Discrete | Telemetry | Operations | NAT | DSIF | Discrete | Telemetry | DSS 12 | DSS 14 | DSS 41 | DSS 42 | DSS 51 | DSS 62 | DSS 71 | ACN | OC | | | | | | | | | |
| SFOF | 10 | JDPS | | JJPL | JDES | JOCE | JZED | JTNC | | | | | | | | JELA | JMLA | AOLA | ANLA | LJLA | LCLA | GKXE | GSXE | GUNV | | GSTS | GKYA | | | | | | |
| | 20 | JJPL | | | JBOS | | JZED | JTNC | | | | | | | | JEXC | JMXA | AOXM | ANXB | LJXO | LCXE | GKXE | GSXE | GUNV | | | GKYA | GKAP | | | | | |
| | 21 | JDPS | | | JDFS | | | JNEC | | | | | | | | JELA | JMLA | AOLA | ANLA | LJLA | LCLA | | GSXE | GUNV | | | GKYA | | | | | | |
| | 28 | JCNF | | | JBQS | | | | | | | | | | | JEXC | JMXA | AOXM | ANXB | LJXO | LCXE | GKXE | GSXE | | | | | | | | | | |
| | 42 | JDPS | | | JBZS | | | JNCC | | | | | | | | JELA | JMLA | AOLA | ANLA | LJLA | LCLA | | GSXE | GUNV | | | | | | | | | |
| | 43 | JDPS | | | JDAS | | | JNDC | | | | | | | | JELA | JMLA | AOLA | ANLA | LJLA | LCLA | | | | | | | | | | | | |
| | 44 | JDPS | | | JDBS | | | JNEC | | | | | | | | JELA | JMLA | AOLA | ANLA | LJLA | LCLA | | | | | | | | | | | | |
| | 45 | JDPS | | | JBZS | | | | | | | JZ(1)D[a] | | | | | | | | | | | | | | | | | | | | | |
| | 46 | JDPS | | | JDAS | | | | | | | JZ(1)D | | | | | | | | | | | | | | | | | | | | | |
| | 47 | JDPS | | | JDBS | | | | | | | JZ(1)D | | | | | | | | | | | | | | | | | | | | | |
| | 70 | JJPL | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | JEXC | JMXA | AOXM | ANXB | LJXO | LCXE | GKXE | GSXE | GUNV | | | | | | | | | |
| | Formats | JDPS | | | | | | | | | | | | JF(1)M[b] | JK(2)M[c] | | | | | | | | | | | | | | | | | | |
| DSS 12 | 20 | JEXC | | | JBNS | | JZED | JTNC | | | JOCC | | | | | | JMXA | AOXM | ANXB | LJXO | LCXE | GKXE | | | | | | | | | | | |
| | 28 | JEXC | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | JELA | JDPS | | JBSS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50/51/55/60 | JECO | | | | | | | | JK(1)M[d] | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | JEXC | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| DSS 14 | 20 | JMXA | | | JBNS | | JZED | JTNC | | | JOCC | | | | | JEXC | | AOXM | ANXB | LJXO | LCXE | GKXE | | | | | | | | | | | |
| | 28 | JMXA | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | JMLA | JDPS | | JBTS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50/51/55/60 | JMAR | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | JMXA | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| DSS 41 | 20 | AOXM | | | JBNS | | JZED | JTNC | | | JOCC | | | | | JEXC | JMXA | | ANXB | LJXO | LCXE | GKXE | | | | | | | | | | | |
| | 28 | AOXM | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | AOLA | JDPS | | JBUS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50/51/55/60 | AOMJ | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | AOXM | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| DSS 42 | 20 | ANXB | | | JBNS | | JZED | JTNC | | | JOCC | | | | | JEXC | JMXA | AOXM | | LJXO | LCXE | GKXE | | | | | | | | | | | |
| | 28 | ANXB | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | ANLA | JDPS | | JBVS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50/51/55/60 | ANBE | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | ANXB | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| DSS 51 | 20 | LJXO | | | JBNS | | JDED | JTNC | | | JOCC | | | | | JEXC | JMXA | AOXM | ANXB | | LCXE | GKXE | | | | | | | | | | | |
| | 28 | LJXO | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | LJLA | JDPS | | JBWS | | | | | | | | | | | | | | | | | | | | | | | GKAP | | | | | |
| | 50/51/55/60 | LJOB | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | LJXO | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |

## Table 5 (contd)

| Transmitting stations | | | Receiving stations | | | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | Space Flight Operations Facility | | | | | | | | | | | | | Deep Space Instrumentation Facility | | | | | | | Goddard | | | | Cape Kennedy | | TAN | CYI | VAN | BDA | MILA |
| | | | Indirect address (JSFO) | | | | | | | | Direct address | | | | | Tracking stations | | | | | | | MSFN | | GRTS | Comm | Building AO | RTCS | | | | | |
| Station | Data | Routing indicator | CPS | Comm | TTY | Operations | NAT | DSIF | Discrete | Telemetry | Operations | NAT | DSIF | Discrete | Telemetry | DSS 12 | DSS 14 | DSS 41 | DSS 42 | DSS 51 | DSS 62 | DSS 71 | ACN | OC | | | | | | | | | |
| DSS 62 | 20 | LCXE | | | JBNS | | JZED | JTNC | | | JOCC | | | | | JEXC | JMXA | AOXM | ANXB | LJXO | | GKXE | | | | | | | | | | | |
| | 28 | LCXE | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | LCLA | JDPS | | JBYS | | | | | | | | | | | | | | | | | | | | | | | GKAP | | | | | |
| | 50/51/55/60 | LCEB | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | LCXE | | | JDDS | | JZJD | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| DSS 71 | 20 | GKXE | | | JBNS | | JZED | JTNC | | | JOCC | | | | | JEXC | JMXA | AOXM | ANXB | LJXO | LCXE | | | | | | GKYA | | | | | | |
| | 28 | GKXE | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 50/51/55/60 | GKEN | | | | | | | | JK(1)M | | | | | | | | | | | | | | | | | | | | | | | |
| | 70 | GKXE | | | JDDS | | JZED | JTNC | JFBM | | | | | | | | | | | | | | | | | | | | | | | | |
| MSFN-ACN | 20 | GSXE | | | JBNS | | JZED | JTNC | | | JOCC | | | | | | | | | | | | | GUNV | | | | | | | | | |
| | 28 | GSXE | | JCNF | JBPS | | | | | | | | | | | | | | | | | | | | | | | | | | | | |
| | 40 | GACN | JDPS | | JDCS | | | | | | | | | | | | | | | | | | | | GDCS | | | GKAP | | | | | |
| | | | | | | | | | | | | | | | | | | | | | | | | | GCDF | | | | | | | | |
| RTCS | 20 | GKAP | | | JBNS | | JZED | JTNC | | | | | | | | | | | | | | | | GUNV | | | GKYA | | | | | | |
| | 21 | GKAP | | | JDFS | | | JNEC | | | | | | | | | | | | LJXO | LCXE | | GSXE | GUNV | GDCS | | GKYA | | LTAN | LCYI | GVAN | | |
| | 22 | GKAP | | | JDGS | | | JNCC | | | | | | | | | | | | | | | GSXE | GUNV | | | | | | | | | |
| | 23 | GKAP | | | JDHS | | | JNDC | | | | | | | | | | | | LJOB | | | | | | | | | | | | | |
| | 24 | GKAP | | | JDHS | | | JNDC | | | | | | | | | | | | | LCEB | | | | | | | | | | | | |
| | Predicts | GKAP | | | | | | | | | | | | | | | | | | | | | | | | | | | LTAN | LCYI | GVAN | GBDA | GMIL |
| GRTS | Predicts | GDCS | | | | | | | | | | | | | | | | | | | | | GACN | GCEN | | | | | LTAN | LCYI | GVAN | GBDA | GMIL |
| MSFN-OC | 20 | GCEN | | | | | | | | | JOCC | | JTNC | | | | | | | | | | GACN | | | | GKYA | | | | | | |
| VAN | | GVAN | | | | | | | | | | | | | | | | | | | | | | GCEN | | | GKYA | | | | | | |
| BDA | | GBDA | | | | | | | | | | | | | | | | | | | | | | GCEN | | | GKYA | | | | | | |
| MILA | | GMIL | | | | | | | | | | | | | | | | | | | | | | GCEN | | | GKYA | | | | | | |
| CYI | | LCYI | | | | | | | | | | | | | | | | | | | | | | GCEN | | | GKYA | | | | | | |
| TAN | | LTAN | | | | | | | | | | | | | | | | | | | | | | GCEN | | | GKYA | | | | | | |

[a]JZ(1)D indicates any 1 of 15 routing indicators.
[b]JF(1)M indicates any 1 of 14 routing indicators (see Fig. 5).
[c]JK(2)M indicates any 1 of 14 routing indicators (see Fig. 5).
[d]JK(1)M indicates any 1 of 12 routing indicators (see Fig. 5).

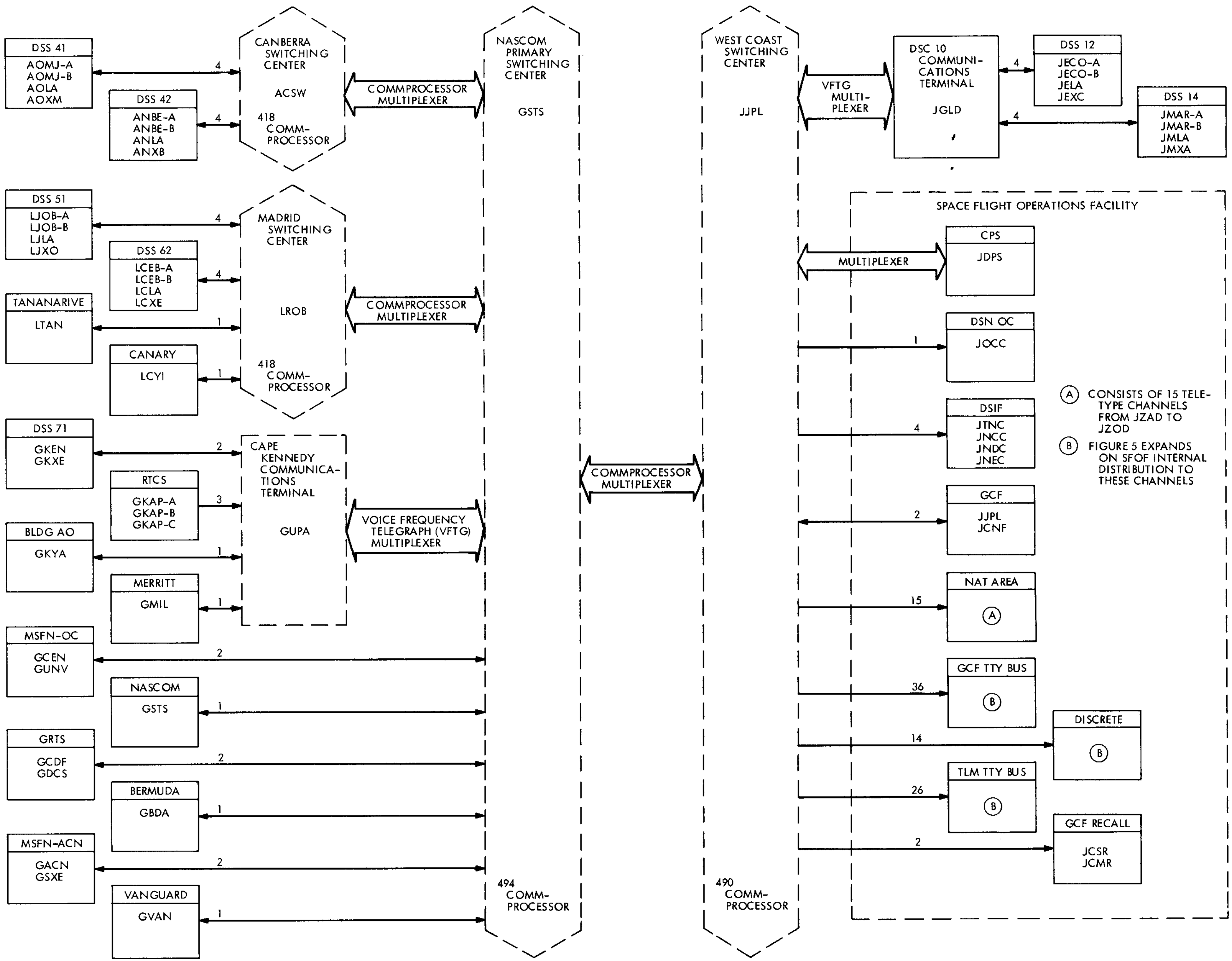


**Fig. 1.** ***Mariner*** **Mars 1971 worldwide teletype network**


**Fig. 2. West Coast Switching Center Univac 490 Commprocessors**

manner desired by *Mariner* Mars 1971 personnel. Figure 2 is a photograph of the WCSC Commprocessor. Two Univac 490 computers are used to provide necessary redundancy.

It would perhaps be informative to illustrate, by example, the end-to-end flow of a specific type of data from the originator multiple addressed to the recipients, illustrating the use of routing indicators, using both direct and indirect addressing techniques. Table 5 reflects that DSS 51 in South Africa must send spacecraft tracking data to the SFOF in Pasadena and to the Real-Time Computing System (RTCS) in Florida. At the SFOF, these data must be supplied not only to the Central Processing System (CPS) but to users in page copy form as well as visually presented on television monitors. The time sequence of this data flow is shown in Table 6.

## VI. SFOF Teletype Data Distribution

During the launch and subsequent phases of the *Mariner* Mars 1971 mission, personnel located within the SFOF must receive, monitor, and analyze various types of teletype data. Such streams of traffic may be sent to the SFOF from external locations, or sent from the SFOF to external locations or generated within the SFOF intended solely for distribution to internal areas. Each operating position having requirements for page copy of teletype data is equipped with one or more teleprinters, each of which is driven by the WCSC Commprocessor since all streams of teletype traffic, regardless of origin or destination, must be routed through this computer. Three methods of distribution from the Commprocessor to user teleprinter equipment have been developed. The first method interconnects 36 teletype output channels to numerous selector boxes capable of selecting any one of the channels for connection to an

**Table 6. Time sequence of data flow from DSS 51 to external addressees**

| Item | Location | Action |
|---|---|---|
| 1 | DSS 51 | a. Originates tracking data in TTY format.<br>b. Multiple addresses TTY messages to GKAP and JSFO adding preamble 51/84/40.<br>c. Transmits TTY messages to Madrid Switching Center using circuit LJLA at 100-word/min rate. |
| 2 | Madrid Switching Center | a. Receives TTY messages from DSS 51.<br>b. Multiplexes messages and transmits to NASCOM Primary Switching Center at 2400 bits/s. |
| 3 | NASCOM Primary Switching Center | a. Receives TTY messages from Madrid Switching Center.<br>b. Demultiplexes messages.<br>c. Reads routing indicator GKAP and transmits messages to RTCS at Cape Kennedy at 100-word/min rate.<br>d. Reads routing indicator JSFO and multiplexes messages to WCSC at 2400-bit/s rate. |
| 4 | RTCS | a. Receives messages from NASCOM Primary Switching Center. |
| 5 | West Coast Switching Center | a. Receives messages from NASCOM Primary Switching Center.<br>b. Demultiplexes messages.<br>c. Reads routing indicator JSFO which instructs Commprocessor to read 51/84/40 preamble.<br>d. Accesses preamble table and determines local routing indicators (JDPS and JBWS) to which traffic is to be routed.<br>e. Transmits messages to JDPS at 40.8 kbits/s. This provides data to CPS.<br>f. Transmits messages to JBWS at 100 words/min. This provides data to GCF TTY BUS for page copy and to associated TTY–TV converter for TV viewing. |
| 6 | Central Processing System | a. Receives messages from WCSC. |
| 7 | SFOF *Mariner* Mars 1971 users | a. Selects messages by depressing button 10 on TTY selector box of GCF TTY BUS (JBWS) for page copy printout.<br>b. Selects messages by depressing button 10 on TV selector switch for visual presentation. |

associated teleprinter. This 36-channel bus arrangement is termed the GCF TTY BUS and is illustrated in Fig. 3. Teletype traffic fed to any of these channels may consist of any of the various types of data except telemetry. The second method interconnects 26 teletype output channels to numerous selector boxes capable of selecting any one of the channels for connection to an associated teleprinter in a manner similar to the first method. This 26-channel bus arrangement is termed the TLM TTY BUS and is illustrated in Fig. 4. The first 12 channels of this bus are allocated for displaying teletype telemetry data incoming from tracking stations (data types 50, 51, 55, and 60). The remaining 14 channels of this bus are allocated for displaying teletype telemetry formats generated by the Central Processing System of the SFOF (360-75 computers). These 14 channels on the bus are not sufficient to display all of the CPS formats. As a result, a third method of distribution has been developed which consists of 14 teleprinters directly connected (no selector box) to the Commprocessor, located within the *Mariner* Mars 1971 operational areas. Figure 5 shows all three of these methods for internal distribution. It should be noted that 24 channels of the GCF TTY BUS and 12 channels of the TLM TTY BUS are connected to TTY–TV converters which provide visual display via television monitors of the traffic carried on these channels. Two additional TTY–TV converters are so configured as to permit *Mariner* Mars 1971 operations


**Fig. 3. Receive only teleprinter with 36-button selector box (GCF TTY BUS)**

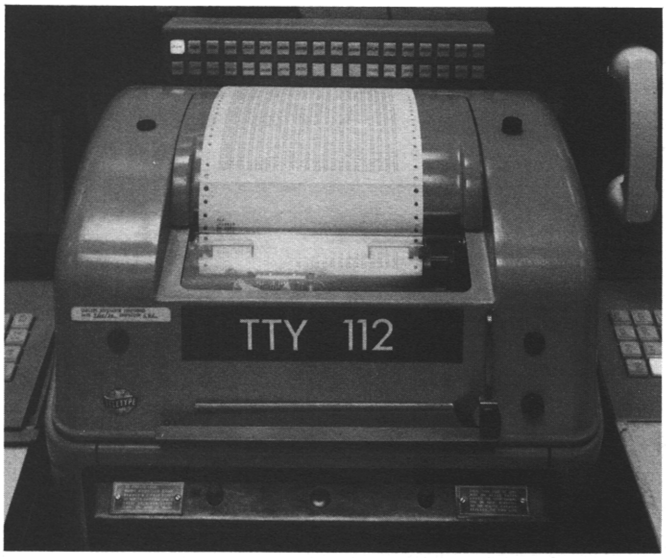


**Fig. 4. Receive only teleprinter with 36-button selector box (TLM TTY BUS)**

personnel to drive them with any desired output teletype format generated by the 360-75 computers so that these outputs may be viewed on television monitors capable of selecting the video outputs of these two converters.

To illustrate, by example, the manner of distributing teletype date incoming to the SFOF, when the tracking station DSS 12 is tracking the first *Mariner* Mars 1971 spacecraft and desires to send tracking data to the SFOF, such traffic will be indirectly addressed by DSS 12 to JSFO followed by the preamble 12/74/40. The selection of the identifiers in this preamble follows the outlines given previously. Table 5 indicates that this indirectly addressed traffic when received at the WCSC Commprocessor will be routed to JDPS (the Central Processing System) and to JBSS on the GCF TTY BUS. Figure 5 reflects that JBSS may be selected for page copy printout by depressing the sixth button on the GCF TTY BUS selector box and may be viewed on television monitors. To illustrate, again by example, the manner of distributing teletype data outgoing from the SFOF, when a message is sent pertaining to the first *Mariner* Mars 1971 spacecraft, containing instructions to DSS 14, such traffic would be directly addressed to JMXA and indirectly addressed to JSFO followed by the preamble 20/74/20. Table 5 indicates that the JMXA routing indicator permits the WCSC Commprocessor to route the traffic to DSS 14 and the JSFO routing indicator together with the preamble is used to internally route the traffic to JBOS on the GCF TTY BUS, to JZED in the Network Analysis Team (NAT) Area, and to JTNC in the DSIF Control Area. Figure 5 reflects that JBOS may be selected for page copy printout by depressing the second button on the GCF TTY BUS selector box and may be viewed on television monitors.

The teletype system used for *Mariner* Mars 1971 message traffic has the capability to receive, transmit, and print out on page copy a multiplicity of symbols which can be divided into three categories: 26 symbols representing the alphabetical characters from A to Z (upper case and lower case), 10 symbols representing the numbers from 0 to 9, and 14 symbols representing punctuation and other meanings as follows:

| Symbol | Meaning |
|---|---|
| – | Dash, hyphen, or minus sign |
| # | Number |
| . | Period, full stop, or decimal point |
| / | Slash |
| ? | Question mark |
| ; | Semicolon |
| " | Quotation or ditto marks |
| : | Colon |
| $ | Dollar sign |
| ' | Apostrophe |
| , | Comma |
| ( | Open parenthesis |
| & | Ampersand |
| ) | Close parenthesis |

Many receiving teleprinters in the SFOF are equipped with standard type-boxes which, upon receipt of the teletype codes assigned to all of the possible symbols, convert these codes and print out the corresponding symbols. Transmission of plain-text *Mariner* Mars 1971 teletype messages uses all of these symbols in the normal conduct of routine operations traffic. Certain types of *Mariner* Mars 1971 teletype messages require that receiving teleprinters have the capability of printing 11 special symbols not normally available in the standard type-boxes. As a result, special modified type-boxes have been developed and installed in appropriate teleprinters

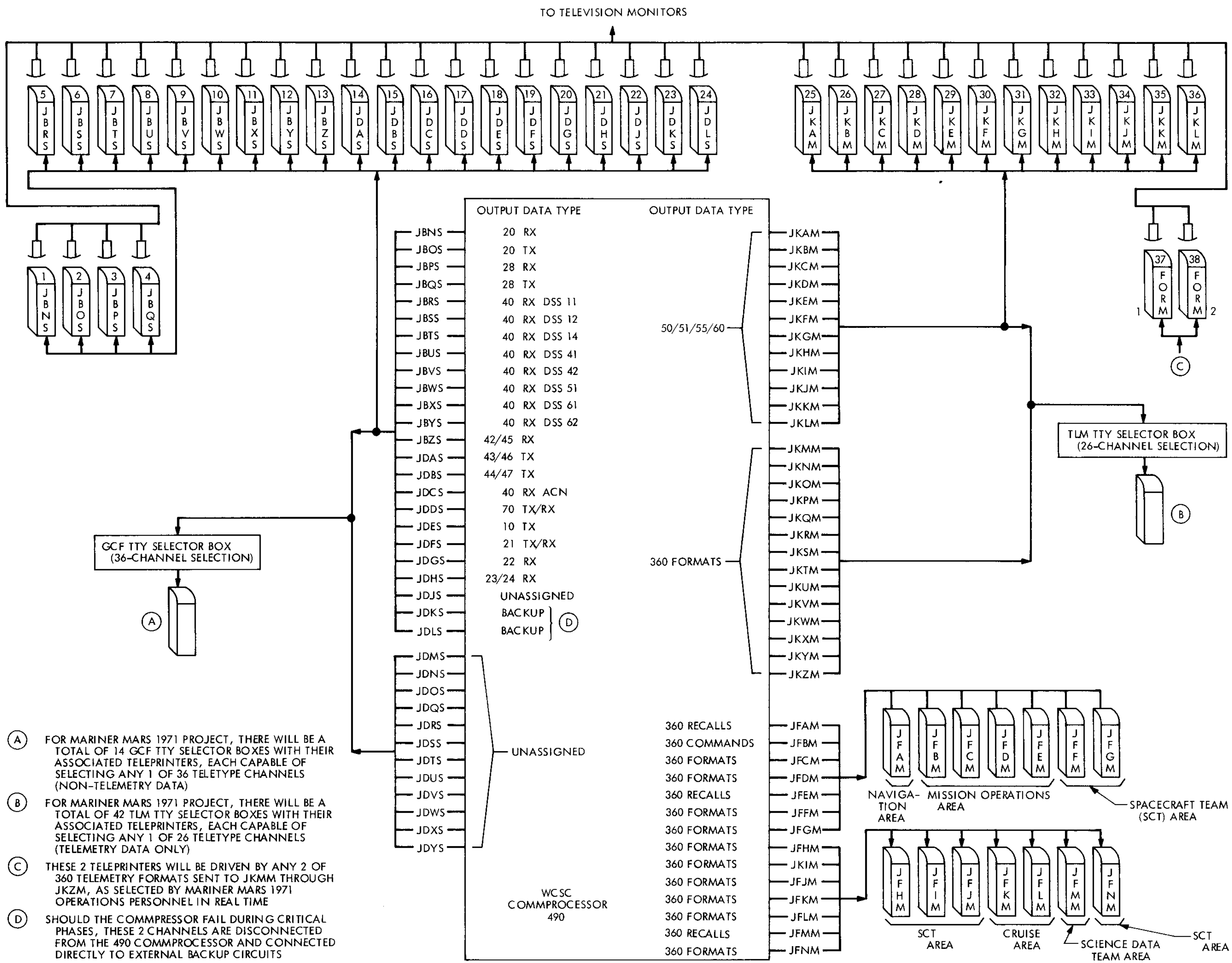


**Fig. 5. Distribution of teletype data to *Mariner* Mars 1971 areas of SFOF**

which delete certain standard symbols and replace them with the special symbols listed below:

| Standard symbol | Converted to | Pronounced | Meaning |
|---|---|---|---|
| ? | + | Plus | Addition |
| ; | * | Asterisk | Alarm |
| " | = | Equal | Equal |
| : | $\underline{0}$ | Bar zero | Ten |
| $ | $\underline{1}$ | Bar one | Eleven |
| ' | $\underline{2}$ | Bar two | Twelve |
| , | $\underline{3}$ | Bar three | Thirteen |
| Open | $\underline{4}$ | Bar four | Fourteen |
| ( | $\underline{5}$ | Bar five | Fifteen |
| & | $\underline{6}$ | Bar six | Sixteen |
| ) | $\underline{7}$ | Bar seven | Seventeen |

Thus, a transmitting station desiring to transmit the *bar one* symbol, meaning eleven, would transmit the teletype code corresponding to the $ and the modified type-boxes on the receiving teleprinters would print the symbol $\underline{1}$.

Occasions will arise during the *Mariner* Mars 1971 missions where any of the recipients of teletype messages in the SFOF may require that certain messages be retransmitted to them a second time. To eliminate the obvious disadvantages of requiring the originator of such traffic to retransmit these messages, provisions have been made in the WCSC Commprocessor that permit the operators of this computer, upon request for such retransmission, to recall the desired messages from the Commprocessor and route these recalls to any teletype channel in the SFOF. It is possible, of course, to route recalled messages to the teletype channel to which the original messages were transmitted, but if this were done, real-time traffic addressed to this channel would be interrupted or delayed by the recalled traffic. To prevent this, two special teletype recall channels, JCSR and JCMR, have been established with associated teleprinters located throughout the SFOF to which recall traffic is routed by the operators of the Commprocessor, thus producing page copy for the requesting user. These two channels are illustrated in Fig. 1. Teleprinters connected to channel JCSR are equipped with standard teletype type-boxes while those connected to channel JCMR are equipped with *Mariner* Mars 1971 modified teletype type-boxes in order to display special *Mariner* Mars 1971 formats.

It is entirely possible during a lengthy tracking pass that streams of teletype traffic sent to the SFOF by several tracking stations may arrive at the WCSC Commprocessor at a higher total bit rate than the teleprinter on the output channel can operate. This is especially true in those cases where a particular type of data coming from several tracking stations is routed to a single-output teletype channel using stacking techniques. As a result, incoming messages may be queued in the Commprocessor awaiting available output time for transmission and, as a result, the data displayed on the output teleprinter will be delayed. To overcome the obvious disadvantages of this, user personnel in the SFOF may request that the operators of the Commprocessor initiate input instructions to this computer which result in the skipping of one or all messages on queue and routing the latest incoming message to the output channel teleprinter, thus providing real-time data to using personnel. All messages skipped in this manner are not automatically forwarded to the user but may be recalled using the methods previously described for recalled traffic.

## VII. Television Distribution of Teletype Data

Within the operational areas of the SFOF, numerous consoles and positions have been equipped with television monitors, each having an associated selector box permitting the user to select many channels of television displays. These television channels display various types of data including equipment status, configurations, mission times, area surveillance, and 360-75 computer outputs. In addition, 38 different channels of both incoming and outgoing teletype traffic may be viewed on these television monitors. Figure 5 identifies these 38 channels, each of which is derived from an output channel of the WCSC Commprocessor and fed to 38 teletype teleprinters individually viewed by the same number of television cameras as shown in Fig. 6. The outputs of these cameras are provided to the selector boxes of each television monitor. Thus, project personnel may select any incoming or outgoing teletype channel for direct viewing on any of numerous television monitors. Figure 7 illustrates a typical *Mariner* Mars 1971 operations console showing two television monitors with their associated selector boxes, and Fig. 8 illustrates a typical desk type television monitor. It should be noted that the first 24 of these teletype–television channels are associated with all types of teletype traffic, such as predicts and tracking data, except telemetry, while the remaining 14 channels are associated with telemetry and commands only. Of these 14 channels, 12 are assigned for viewing


Fig. 6. Teletype to television converters

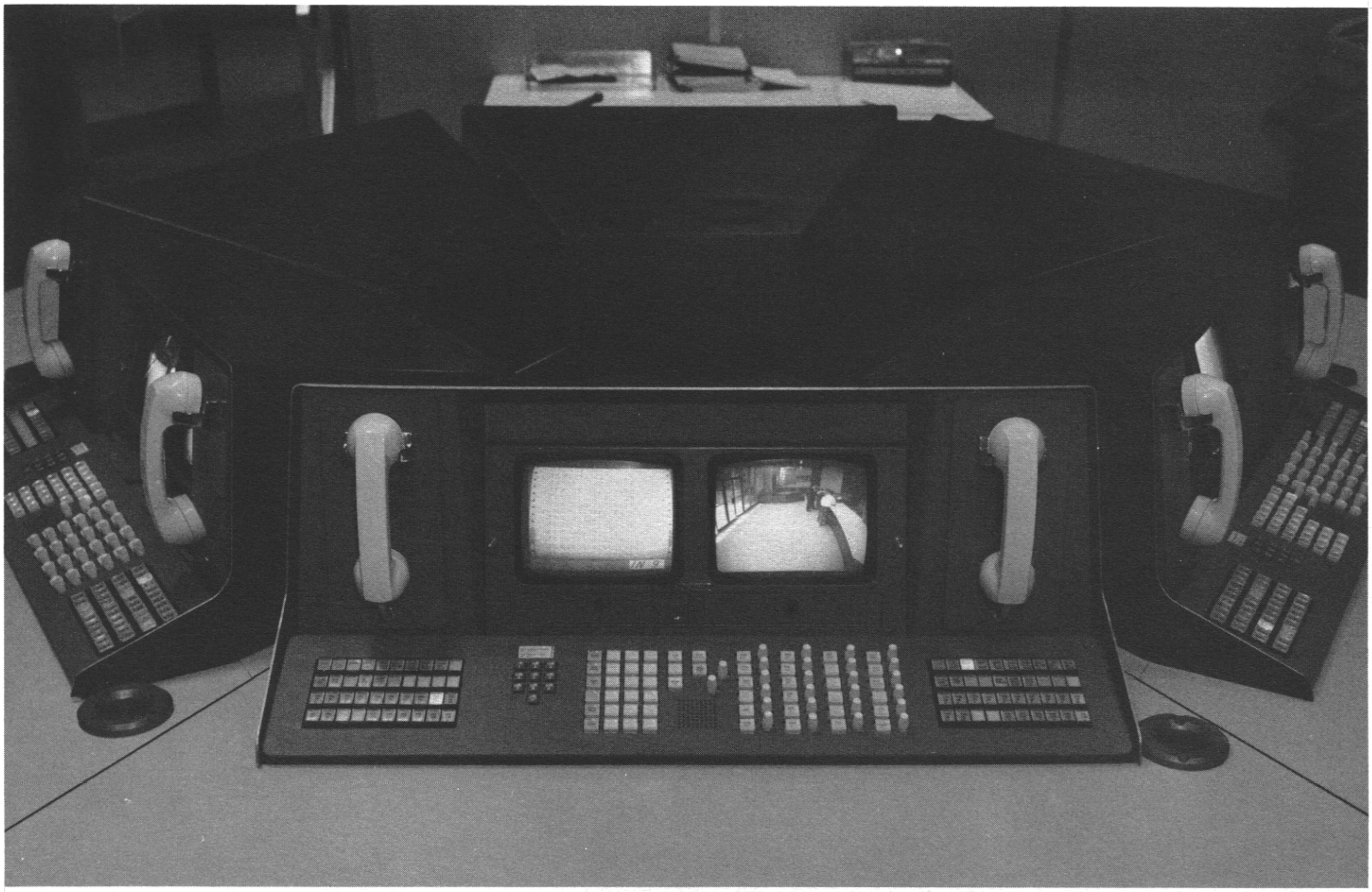

Fig. 7. *Mariner* Mars 1971 operations console

incoming raw teletype telemetry from the tracking stations while the remaining 2 channels are user selectable for viewing any of the teletype-formatted telemetry outputs of the 360-75 computers as derived from the telemetry data furnished to these computers by the inbound high-speed data circuits.

## VIII. Teletype Backup Circuits

The overall design and mission configuration of the entire teletype system provided for the *Mariner* Mars 1971 Project, by the DSN GCF and NASCOM, requires that all agencies and stations transmitting or receiving teletype traffic be directly connected to one of the four Commprocessors at one of the switching centers. Certain streams of teletype data may pass only through a single Commprocessor, such as traffic originating at DSS 12 at Goldstone, California destined for transmission to the SFOF, while other streams may pass through as many as three Commprocessors, such as traffic originated by DSS 51 in South Africa destined for transmission to the SFOF. In all cases, however, since all teletype traffic must pass through at least one Commprocessor, a failure of any one of the four during critical phases of the *Mariner* Mars 1971 mission could result in non-receipt at the SFOF of data that could have critical importance to mission personnel.

NASCOM, in conjunction with the DSN GCF, has developed limited capabilities which, when activated, will permit certain selected streams of teletype traffic inbound to the SFOF from any of nine supporting locations to be bypassed around the Commprocessors and provided in raw form to mission personnel as illustrated by Fig. 9. Since the interface between any two of the Commprocessors is dependent upon the proper operation of both, then a failure experienced by one necessitates that all Commprocessors in the teletype stream must be bypassed from the originating station to display devices in the SFOF. Although nine different locations are supported by these bypass capabilities, only combinations of two stations can be used simultaneously and combinations of DSS 41 with DSS 42 and DSS 51 and DSS 62

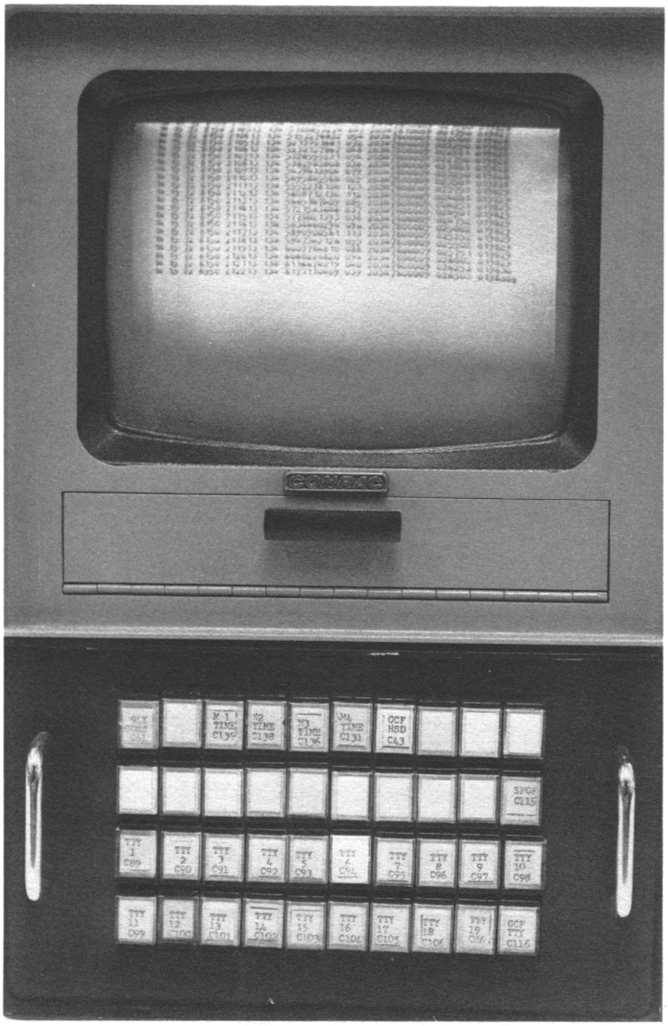

**Fig. 8. Television monitor and selector box**

are not possible. These restrictions are a result of the availability of only a few discrete teletype circuits to the overseas switching centers and only two display channels in the SFOF. Upon receipt of the two bypass teletype streams, the WCSC connects these to output channels 23 and 24 on the GCF TTY BUS, which may be selected by mission personnel for page copy printout or for television viewing.

During the two launches scheduled for *Mariner* Mars 1971, certain portions of the total bypass capability illustrated in Fig. 9 will be pre-scheduled and activated by communications personnel. Certain streams of teletype traffic, such as that originated by the MSFN tracking stations at Ascension Island, will be transmitted to the SFOF not only by the normal Commprocessor route but also by the bypass circuits activated for this purpose until loss of signal by the tracking stations. In the event of a Commprocessor failure resulting in interruption of the normal streams, the data arriving via the bypass circuits will immediately be available for use. During subsequent cruise phases of the mission, activation of bypass circuits to DSN tracking stations will be made only as required by either spacecraft maneuvers or spacecraft emergencies when receipt of teletype data is vital to operations. Since the prime method of telemetry transmission is over the high-speed data system and since this system is independent of Commprocessor failures, it is not anticipated that these bypass circuits will be used for transmission of telemetry data.

## IX. Conclusion

A considerable amount of advanced planning has been accomplished for all types of communications support for the two *Mariner* Mars 1971 missions, not only by personnel of the *Mariner* Mars 1971 Project and the DSN GCF but by elements of the DSIF, SFOF, MSFN, and NASCOM as well. As a result, the teletype system developed for the support of the *Mariner* Mars 1971 missions undoubtedly represents the highest development of this communications discipline used for any mission supported by the DSN.

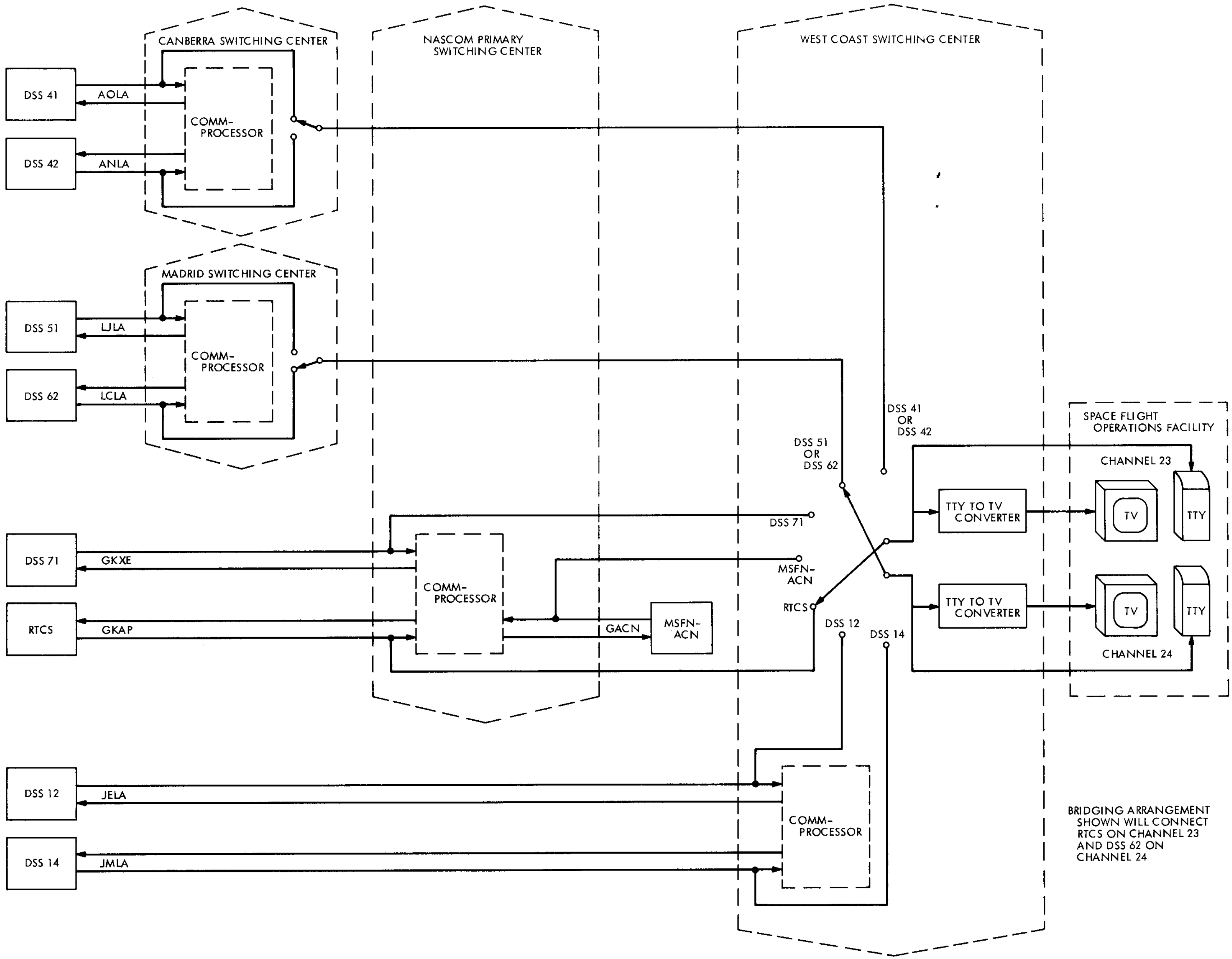


**Fig. 9.** ***Mariner*** **Mars 1971 teletype backup circuits**